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Control of Japanese Beetle Grubs

Part I. Treatment of Lawns

By B. R. Leach and J. W. Lipp

Part II. Treatment of Nursery Stock

By B. R. Leach and W. E. Fleming

United States Bureau of Entomology

Applying Liquid to Lawn in Control of the Japanese Beetle

C. G. Jordan, *Secretary of Agriculture*
C. H. Hadley, *Director, Bureau of Plant Industry*

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FIGHTING THE JAPANESE BEETLE

The Japanese beetle work is being conducted jointly by the United States Department of Agriculture and the Departments of Agriculture of the States of Pennsylvania, New Jersey, New York, Connecticut, and Delaware. The work includes not only enforcement of quarantines affecting the restriction and the spread of the insect through the movement of various plant carriers, but also the development of practical measures of control and prevention of damage by the insect, studies of the habits of the insect under the various conditions which prevail throughout the infested territory, and the introduction and dissemination of natural enemies or parasites from the home of the insect in the Orient to the infested territory in this country.

The Japanese beetle has developed to a point in southeastern Pennsylvania where it is causing damage both by the beetle and the grub or larval stage of the insect. This bulletin has been prepared by members of the Japanese Beetle Laboratory at the request of the Pennsylvania Department of Agriculture to furnish information as to the methods which may be followed for the prevention of damage to lawns, golf courses, and other grassy areas, and to give directions for the treatment of soil about roots of plants which may be intended for shipment in connection with the nursery industry in the southeastern portion of the state.

Other information relating to the Japanese beetle may be secured without charge upon request of the Department of Agriculture at Harrisburg, Pa., or the Japanese Beetle Laboratory at Riverton, N. J.

Control of Japanese Beetle Grubs

PART I. TREATMENT OF LAWNS

By B. R. Leach and J. W. Lipp,
Bureau of Entomology, U. S. Department of Agriculture

When lawns or golf greens become heavily infested with the larvae (grubs) of the Japanese beetle it becomes necessary to kill the grubs before they ruin the sod or turf. The most satisfactory method of killing this insect in turf consists of treating the turf with emulsified carbon disulfide, diluted with water. The treatment is best applied in late summer, at which time the grubs are only about half grown and have not as yet injured the grass to any appreciable extent.

PREPARATION OF THE EMULSION

Two carbon disulfide emulsion formulae are herewith presented, each having special merits as discussed below:

Emulsion No. 1. The ingredients of this emulsion consist of 10 parts by volume of carbon disulfide,[1] 1 part by volume of cold-water-soluble rosin fish oil soap and 3 parts by volume of water. Prepare the emulsion in a wooden butter churn (Fig. 5) or ice cream freezer as follows: place the soap and water in the churn and turn the handle for a few moments in order to obtain an even mixture. Then add the carbon disulfide to the mixture of soap and water in the churn and turn the handle for about two minutes or until the mixture emulsifies as indicated by the change in color and the cream-like consistency of the liquid.

This emulsion is valuable in that the ingredients are readily obtainable and easily emulsified with simple apparatus. This formula is recommended when the emulsion is to be used in lawn treatment immediately after mixing, as would in all probability be the case when the emulsion is made at home. The emulsion has one disadvantage in that on standing in containers for any length of time it has a tendency to separate or stratify and must be thoroughly shaken before being used for lawn treatment. Shaking large containers of emulsion is a laborious and uncertain process.

Emulsion No. 2. Make up a soap solution as follows: To 135 cc. of 7 per cent sodium hydroxide solution, add 50 grammes of powdered rosin. Then add 450 cc. of water and agitate thoroughly. Add 50 cc. of oleic acid and again agitate thoroughly. The best grades (C. P. or

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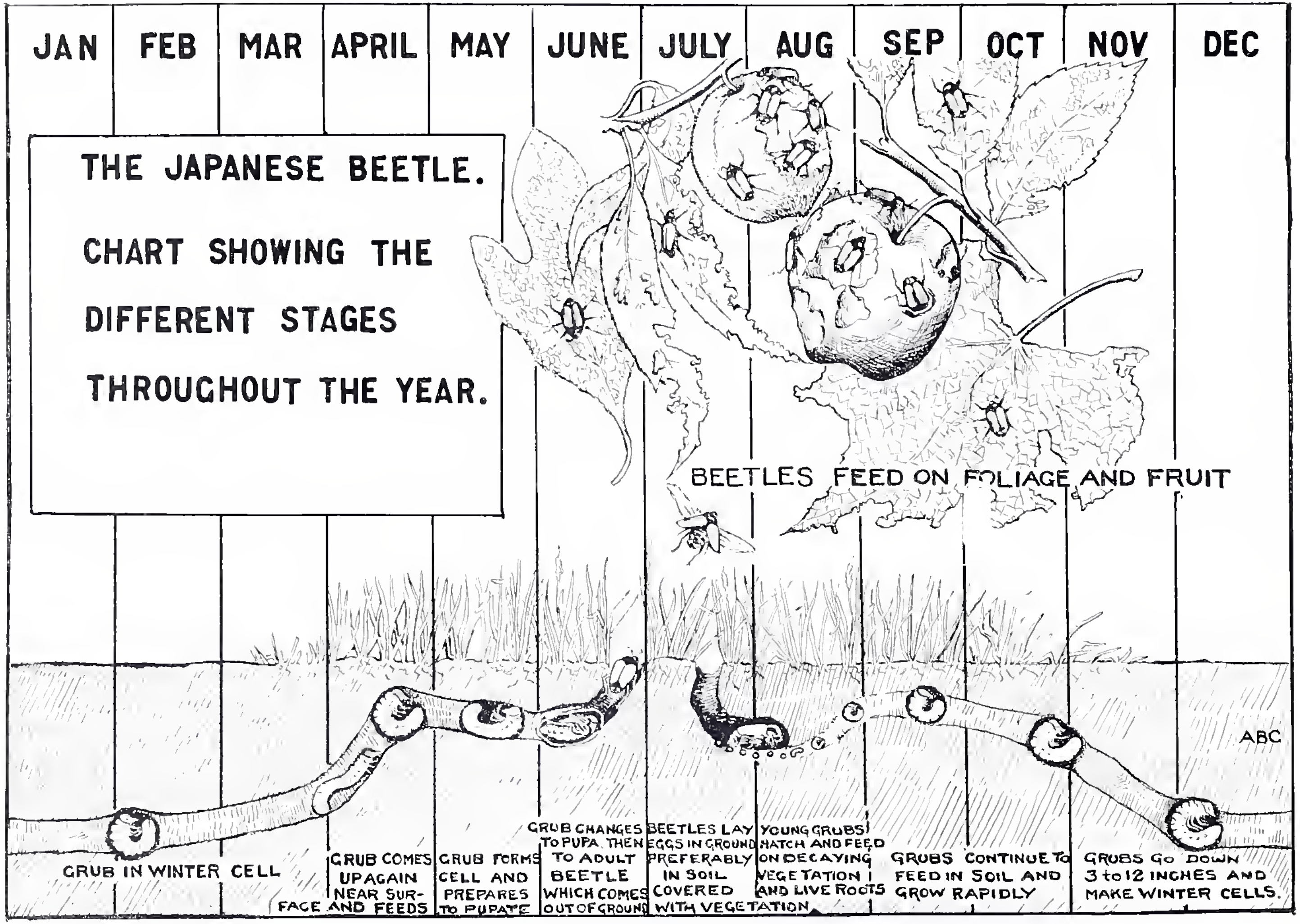
[1] Pure carbon disulfide is a colorless liquid, insoluble in and heavier than water. It is readily volatile and the vapor is highly inflammable. It can be secured at most drug stores.


JAN
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THE JAPANESE BEETLE.
CHART SHOWING THE
DIFFERENT STAGES
THROUGHOUT THE YEAR.
BEETLES FEED ON FOLIAGE AND FRUIT
ABC
GRUB IN WINTER CELL
GRUB COMES UP AGAIN NEAR SURFACE AND FEEDS
GRUB FORMS CELL AND PREPARES TO PUPATE
GRUB CHANGES TO PUPA, THEN TO ADULT BEETLE WHICH COMES OUT OF GROUND
BEETLES LAY EGGS IN GROUND PREFERABLY IN SOIL COVERED WITH VEGETATION
YOUNG GRUBS HATCH AND FEED ON DECAYING VEGETATION AND LIVE ROOTS
GRUBS CONTINUE TO FEED IN SOIL AND GROW RAPIDLY
GRUBS GO DOWN 3 to 12 INCHES AND MAKE WINTER CELLS.

Fig. 1. Diagrammatic illustration of the life-cycle of the Japanese Beetle.

U. S. P.) of sodium hydroxide, rosin and oleic acid should be used. Thirty parts of the above soap mixture is added to 70 parts of carbon disulfide and the mixture agitated in a churn until emulsification occurs.

This emulsion has the advantage of not separating or stratifying but very slightly when stored and is therefore the preferable one of the two for those buying the emulsion in large drums from commercial concerns, since no shaking of the containers is necessary.

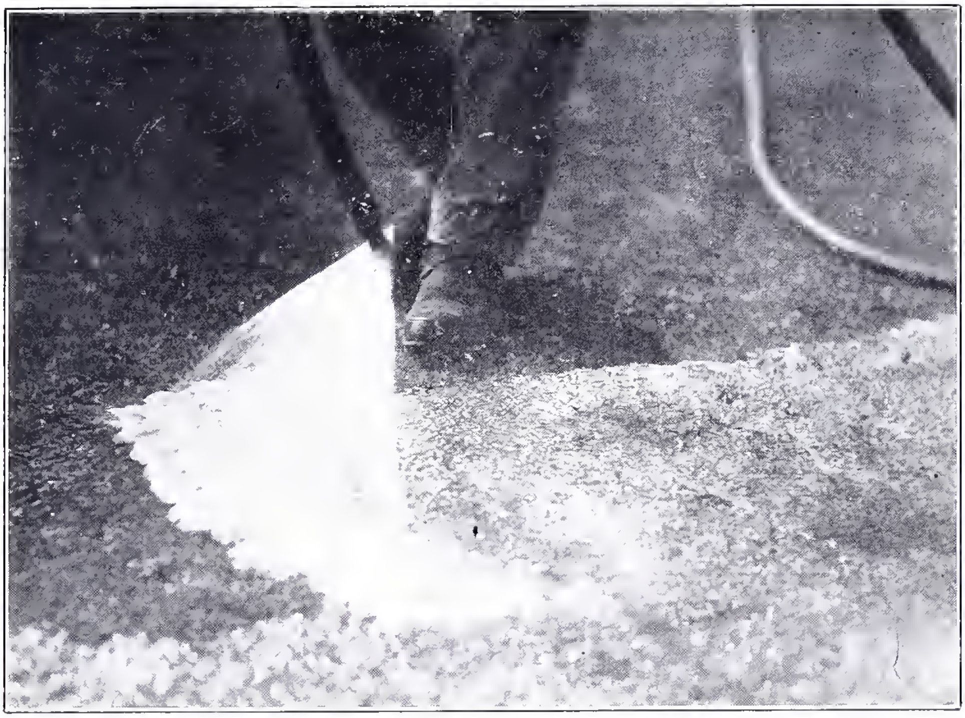

Fig. 2. Special nozzle in operation. (U. S. Dept. Agr.)

Caution: Carbon disulfide is extremely inflammable and explosive and must be handled with the same degree of care as gasoline.

TREATMENT OF LAWNS

Equipment. The emulsion may be diluted in any container, varying from a watering pot or barrel pump to a large tank with engine and pump, depending in a measure upon the area of turf to be treated and the facilities available. It may also be applied by means of the mixing machine (Fig. 4) which will be described later.

Small lawns, such as ordinarily surround the average urban or suburban house, can be treated by the owners with ordinary home utensils. For this purpose a tub or barrel for mixing the stock emulsion and a watering pot with a coarse nozzle for applying the liquid to the turf are all that is necessary. Mix the carbon disulfide emulsion with water in the tub or barrel at the rate of one quart of the emulsion to 50 gallons of water, and apply the resulting liquid to the turf at the rate of one quart per square foot. For smaller amounts use one tablespoonful of emulsion to one gallon of water. This amount cannot be applied all at one time to the turf without flooding. It will be necessary to water the lawn with the liquid up to the point where flooding and puddling is imminent, and then allow the liquid to soak in for a few minutes before applying the remainder of the allotted quantity. The nozzle of the watering pot should be held within a few inches of the ground during the operation so as to avoid as much as possible the loss of the toxic gas from the liquid.

In the event of a barrel pump being used the liquid may be mixed in the barrel, pumped out through a hose and applied to the turf by means of the nozzle shown in Fig. 3. Before mixing the carbon disulfide emulsion with water in the barrel, care should be taken that the latter is entirely clean.

TREATING LARGE LAWNS AND GREENS

Equipment. The method in general is indicated by the accompanying illustrations. The outfit employed for this work should consist of a motor truck or wagon upon which is mounted a tank with pump and regulator. (See cover page.) The main supply hose from the tank leads to a pipe, as shown, from which four leads of one-inch hose (each with a cut-off valve) carry the liquid to the green. At the end of each line of inch hose is a special nozzle, devised at this laboratory, for the specific purpose of properly flowing the liquid upon the lawn (Fig. 2). In other words, the liquid is not sprayed upon the green under pressure; it is poured or flowed on the turf.

Preparation of the Green for Treatment. Since the liquid is applied at the rate of one quart per square foot of turf, it follows that each tank of liquid will treat an area of lawns equal to four times the capacity of the tanks in gallons. As an example, suppose the tank holds 450 gallons of liquid. This amount of liquid would therefore treat 1,800 square feet of lawn. In practice, therefore, beginning at one side of the green, strips of turf the length of the green, each comprising an area of 1,200 square feet, are laid out and marked by lines of coarse twine, and a line of hose, with nozzle attached, is then laid the length of each of the three strips, as shown in Fig. 6. Everything is now in readiness to apply two successive tanks of liquid to the 3,600 square feet of the green marked out as above. The size of the areas of turf so lined out would depend entirely on the size of the tank.

Applying the Liquid to the Turf. Under the above arrangement the 3,600 square feet area of lawn is divided into three equal parts. Each part is treated with 300 gallons of liquid by a workman who confines his efforts to his own strip of turf (see cover page). By this method the liquid is applied in an orderly and systematic fashion and the chance of uneven distribution of the liquid is reduced to the minimum. Furthermore, any faulty work on the part of the individual workman, resulting subsequently in poor grub kill or burning of the lawn, can be corrected.

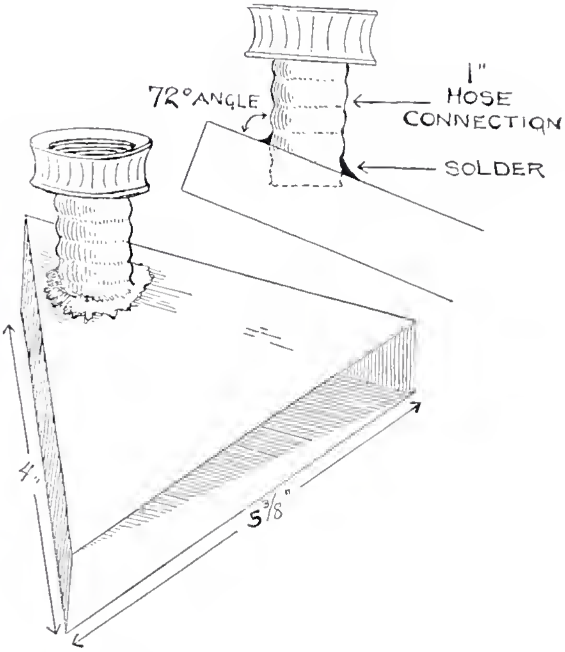

Fig. 3. Working drawing of the special nozzle for treating golf greens and lawns. (See Fig. 2 for nozzle in operation.)

Manipulation of the Nozzle. The special nozzle is shown in operation in Fig. 2 and on the cover page. It will be observed that the liquid flows from the nozzle in a fan-like stream, and that the nozzle is held about 4 to 8 inches from the ground. The operator, beginning at one end, slowly moves over his strip of lawn, from side to side, covering the ground with a layer or coat of liquid, avoiding puddling or excessive run-off, and taking care not to leave any untreated streaks. The experimental work has indicated that, in applying the liquid at the rate of one quart per square foot of turf, it is advisable to regulate the speed of application so that the workman will have gone over the strip once when the first of the two tanks of liquid is emptied. While the tank is being refilled the turf will have absorbed the liquid already applied sufficiently so that the second tank can be applied in the same way as above without excessive run-off or puddling. In this respect, *the danger from applying another layer of liquid before the previous one has been absorbed by the turf cannot be emphasized too strongly. Severe burning will result if care is not taken in this respect.*

On the other hand, while too heavy coating of the turf must be avoided, the operator must not swing to the opposite extreme and apply several light coatings. There will be no burning under the latter conditions, but the grub kill will be unsatisfactory. Under the circumstances, it seems advisable to follow a medium course by applying the one quart per square foot in two even coats.[1]

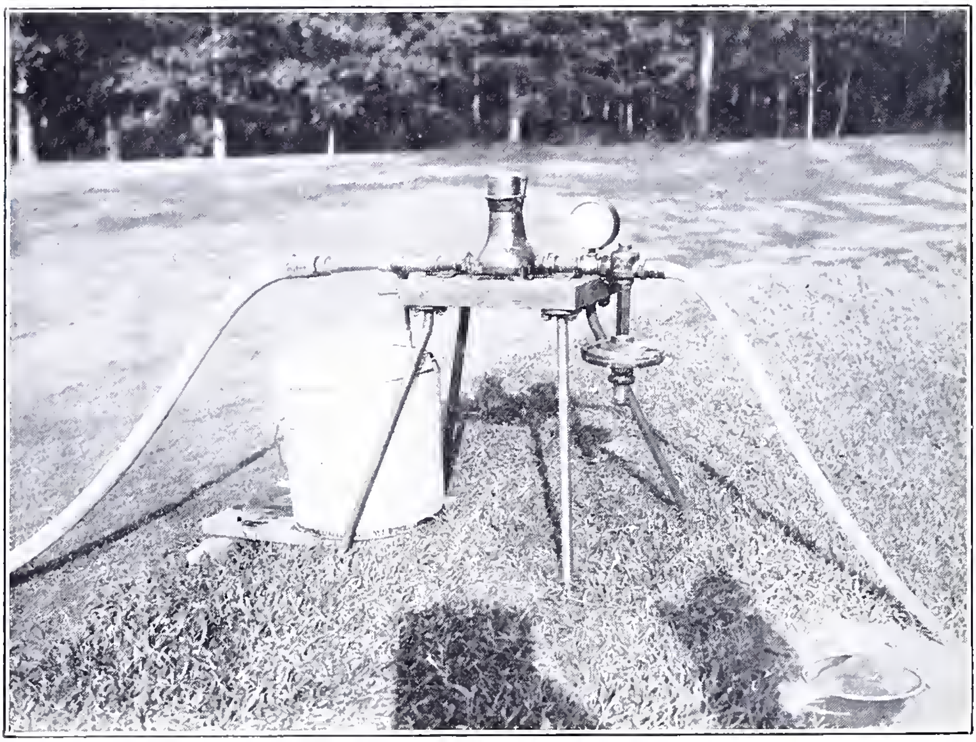

Fig. 4. The mixing machine set up on the side of the green. (U. S. Dept. Agr.)

Treating Turf with the Mixing Machine. Treating turf with carbon disulfide emulsion by means of a tank and pump outfit, as described above, is a very efficacious method as far as the attaining of the desired result is concerned, but the necessary apparatus is expensive and clumsy in actual use. These aspects of the case were responsible for the experimental work carried on by Mr. G. Gordon Urquhart, a chemical engineer of Philadelphia, in cooperation with this laboratory, resulting in the invention of the machine illustrated in Fig. 4.

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[1] To test the turf as to whether it is in condition to receive another coating of liquid, press the foot upon the turf; if the liquid oozes out under the pressure of the foot, the turf should be allowed to drain until this condition no longer exists.

The machine is based upon the principle that a stream of water flowing under pressure through a pipe is capable of creating a suction. Under this condition the water from the hydrant enters the machine through the hose on the right hand side and passes through the pressure regulator and water meter. It then flows through a constricted pipe, making a jet, which shoots across an enlarged chamber and out through the pipe and inch hose. To this enlarged chamber is attached a thin tube (3/16-inch diameter), with needle valve, which extends down into the pail containing the stock carbon disulfide emulsion. The jet of water, shooting across the enlarged chamber, creates the suction which draws up the carbon disulfide emulsion from the container into the enlarged chamber where it mixes with the main body of water and flows out through the inch hose to the green. The needle valve is so adjusted by the operator that one quart of stock emulsion is sucked up by each 50 gallons of water passing through the machine.

This machine, as now manufactured, is obtainable for less than $100. Its value is apparent since it does away with the necessity of expensive tanks and pumps and effects a 75 per cent reduction in the expenditure for rubber hose. Two men, with this outfit, can do the work requiring five men with the tank and pump method.

Many golf greens in New Jersey have been treated, using this type of machine, with very satisfactory results. As a result of this experience certain minor changes and adjustments have been made which should contribute toward simplicity and smoothness of operation in practice.

Adjusting the Machine. Set the machine up alongside the green or lawn to be treated and connect it to the hydrant or faucet. Turn on the water and determine the pressure by means of the gauge. Now tighten the pressure regulator so that the pressure drops ten or fifteen pounds, thus insuring a steady pressure and uniform flow of water regardless of fluctuations in the water supply. Close the needle valve. Lift up the machine and place a gallon measure under the thin suction tube or pipe. Pour a quart of water into the measure. It is cheaper and better to use water alone than carbon disulfide emulsion for the adjustment of the machine. Now open the needle valve to any tentative degree, taking the reading on the water meter at the time and then allow 50 gallons of water to flow through the machine. If the quart of water in the can is sucked up before the 50 gallons have run through the machine, close the needle valve in proportion and test the adjustment with another quart of water. A very little experience with the machine will enable one to adjust the needle valve so that one quart of liquid is sucked up for each 50 gallons of water flowing through the machine.

Precaution before Treating. If the upper 2 or 3 inches of the turf dries out the grubs go below this dry layer and it is difficult to kill them under these conditions. It is advisable therefore to maintain the turf in a moist condition for 2 or 3 days prior to treatment so that the grubs will be near the surface.

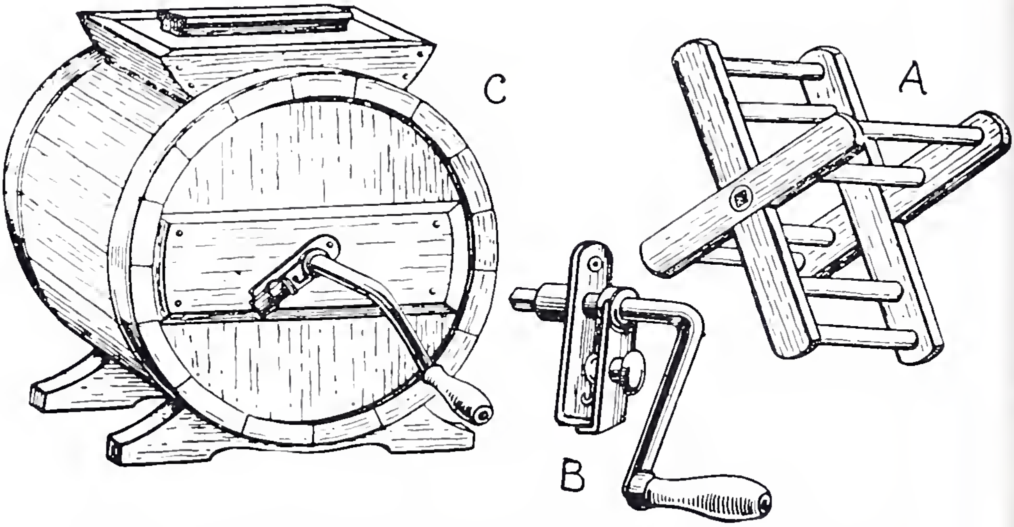

Fig. 5. A desirable type of churn for use in the preparation of carbon disulfide emulsion. (U. S. Dept. Agr.)

Applying the Liquid to the Lawn or Green. Having adjusted the machine as above, replace the gallon measure with the large covered container (Fig. 4) and place therein a gallon or two of stock carbon disulfide emulsion. The machine is now ready for the application of the liquid to the green.

The method of lining out the green or lawn for treatment with the machine is shown in Fig. 6. Having placed the machine in the position A, with one hundred feet of inch hose attached, it is possible to treat the area A B C when the distance A C is less than 100 feet. Having treated this area the adjoining section of turf is treated by moving the machine to the position D. The distance from the hydrant to the machine is governed only by the quantity of pipe or ¾-inch hose available, but it is not advisable to employ more than 100 feet of inch hose for delivery from the machine since longer lengths of hose create too great a back pressure upon the suction chamber.

The turf is best treated in strips about 10 feet wide, the strips being designated by lengths of coarse twine. Beginning at the left (Fig. 6), coat strip No. 1 with the liquid as described on page 7, applying an even coat and avoiding excessive flooding or run-off. When No. 1 strip is covered proceed with No. 2. If No. 1 strip has drained properly in the interval give it another and final coating. If No. 1 is not ready for the second coat of liquid proceed with the first coating of No. 3 strip. Following this procedure the application of the liquid is continuous and no time is lost through waiting. Two coatings made in this fashion will be found to closely approximate an application of 1 quart per square foot of turf. It can be checked by comparing the liquid going thru the meter with the area treated.

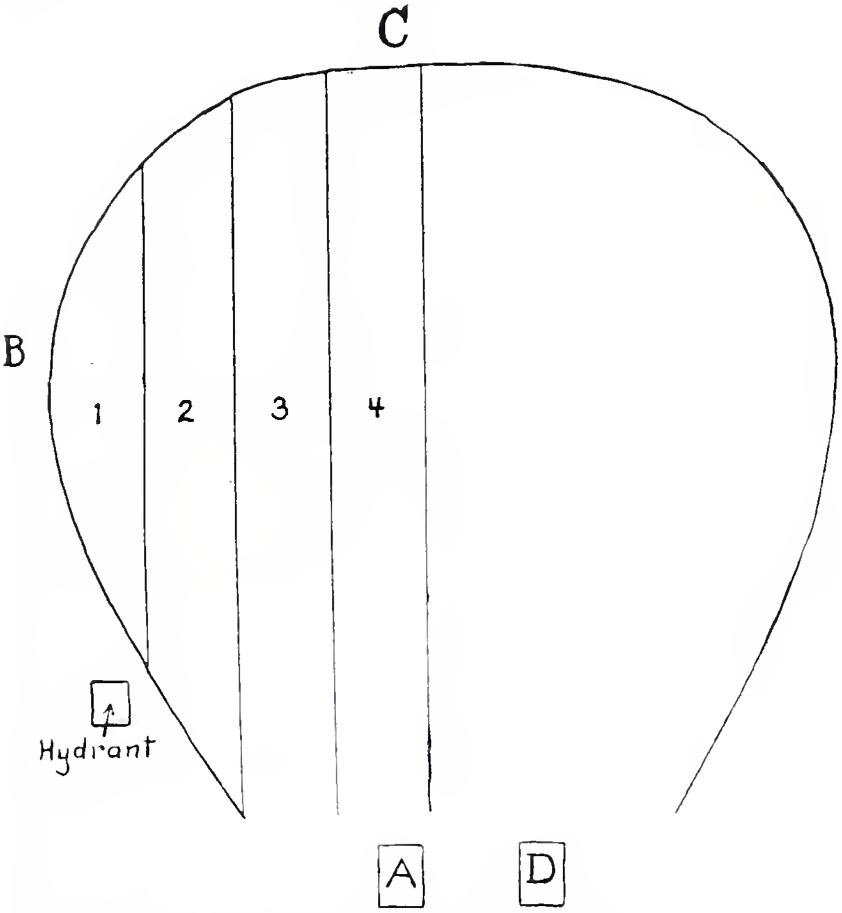

Fig. 6. Layout of a lawn or green for treatment with the mixing machine. (U. S. Dept. Agr.)

Two men are necessary for the proper operation of this machine. One man will be occupied in handling the hose and nozzle in connection with the actual application of the liquid to the turf. The duties of the second man will consist in keeping the machine supplied with stock carbon disulfide emulsion, marking the boundaries of the strips of turf with the lengths of string and assisting the first workman in handling the 100 feet length of hose.

EFFECT OF TREATMENT UPON GRASS

Various grasses have been treated during the course of the experimental work, including clover, red top, low spear-grass, fescue, German and creeping bent. All these grasses withstood the treatment when the turf was not in a weakened condition caused by grub feeding on the grass roots. The only injury encountered in treating vigorous turf consisted in surface burning in hot weather and injury to low spots in the turf where the liquid puddled. For this reason it would seem advisable to have the greens or lawns in the Japanese beetle area so graded that these hollows are obviated. As stated above, the treatment of vigorous turf in hot, sunshiny weather sometimes results in a browning of the blades of grass, thereby giving the green or lawn a burnt appearance. If watered daily, however, the crowns of the grass soon send up new shoots and the green assumes a normal appearance within two weeks. Treatment in extremely hot weather is therefore not advised, except when the grubs are threatening serious damage to the turf if treatment is delayed, in which even the burning due to the treatment under these adverse conditions will be the less of the two evils.

When the treating of infested turf is delayed until it is in a weakened or damaged condition due to grub feeding, the effect of the treatment upon such turf is an entirely different matter. In these instances the turf has little or no resistance to the chemical. It should be top dressed and reseeded in a few days after treatment.

Treating normal turf with emulsified carbon disulfide also results in a pronounced stimulation in the growth of the grass. Vigorous growth and a deepening in the color of the grass is apparent a week or ten days after the treatment.

COST OF THE TREATMENT

It will cost approximately twenty dollars for the emulsion and labor to treat a green or lawn 80 feet wide by 90 feet long, the cost of the emulsion accounting for about two-thirds of this sum. The emulsion may be purchased for about 15 or 16 cents a pound in 500 pound lots, or the ingredients may be purchased separately and emulsified at home.

In the latter event the saving is not commensurate with the amount of work and trouble involved.

CARE OF THE TURF AFTER TREATMENT

The turf should not be disturbed in any way for 36 to 48 hours after treatment. By the end of that period the excess water has usually drained away and the turf can be top dressed or otherwise cared for.

CONTROL OF JAPANESE BEETLE IN LAWNS WITH ARSENATE OF LEAD

Five years of experimental work, conducted at the Japanese beetle laboratory, have shown that arsenate of lead, when mixed with the upper soil layer will control grubs and worms and will not unduly influence the growth of the majority of grasses commonly used in golf greens and lawns.

The grasses which have grown successfully in soil poisoned with arsenate of lead are creeping bent, perennial rye grass, German mixed bent, Chewing's fescue, sweet vernal grass, Kentucky blue grass and meadow fescue.

Effect of Arsenate of Lead on Grubs. When arsenate of lead is mixed with the soil of a lawn or golf green at the rate of 1,500 pounds to the acre (3½ pounds per 100 square feet), it kills the grubs and worms. Experiments show that turf so poisoned has remained grub-proof over a period of five years. How much longer this will continue we are unable to say at this time.

Effect of Arsenate of Lead on Grass. Experimental work covering three years shows that far from being injured by the arsenate of lead, the grasses used on lawns are actually stimulated by the presence of this material in the soil. Bent grass growing in poisoned soil is more vigorous and dense and has a better color than that growing alongside in unpoisoned soil. The results would seem to indicate that in the case of poisoned turf the extensive use of nitrogenous fertilizers will not be necessary to such a great extent.

Weed Growth in Poisoned Soil. The term "weed" as used in this connection refers to any plant growth whose presence is undesirable in fine turf. Among those which may be mentioned are crab grass, chickweed, dandelion, sour dock, etc. Most of these weeds do not grow well in poisoned soil. They are stunted in their growth and the percentage of the germination of weed seeds is very small.

Building a Poisoned Lawn or Green. The area of the lawn should be calculated accurately. Let us suppose that the area of the lawn in question is 5,000 square feet. One hundred seventy-five pounds of arsenate of lead (3½ pounds per 100 square feet) should be thoroughly mixed with a cubic yard of dry soil or sand. The use of heavy clay or loam is not advisable. There is some labor connected with this operation but it has been found necessary in practice for the following reasons:—(1) arsenate of lead is a light, fluffy powder and any attempt to dust it on the surface of the soil results in a large loss due to its blowing away. (2) It is a very difficult matter for the novice to apply 3½ pounds of arsenate of lead evenly to 100 square feet. For these reasons the arsenate of lead is mixed with the soil first, thereby preventing the loss by blowing, and giving a large bulk which can be spread over the surface to be treated with a smaller percentage of error. In this connection please remember that the poison must be evenly distributed over the area to be poisoned. Any carelessness in this respect will result in a spotty, uneven control of the grubs.

Having mixed the arsenate of lead with the soil it can then be applied to the surface of the soil by hand or by means of a top dressing spreader. As soon as it has all been spread on the surface the material should be worked in to a depth of 3 inches with a disc harrow or with a hoe in the case of small lawns. This discing should be done both ways across the lawn. After discing, harrow with a spike, spring-tooth, or, preferably, a Meeker harrow. In the case of small lawns, smooth with a rake. When properly done, these implements leave the surface smooth. The soil is now ready for seeding.

Fertilizing Lawns Growing in Poisoned Soil. The use of ammonium sulfate and well rotted manure is permissible, but do not fertilize before or after planting, at any time, with lime, acid phosphate, potash salts or mixed fertilizers. These materials are not compatible with arsenate of lead.

PART II

Treatment of Nursery Stock[1]

By B. R. Leach and W. E. Fleming,
Bureau of Entomology, U. S. Department of Agriculture

The area infested by the Japanese beetle is one of the most important ornamental nursery sections of the United States. The soil about the roots of plants of this type is known to be subject to infestation by this insect. The inter- and intra-state movement of this type of nursery stock is therefore regulated by law with the object of preventing the insect's spread. In view of the above circumstances, work was begun in 1920 at the Japanese Beetle Laboratory with the object of devising methods of chemically treating soil about the roots of plants so as to destroy any grubs. As a result of three years of experimentation, it was found that carbon disulfide is the only chemical capable of being used for this type of soil treatment.

The method of treatment finally evolved consists in placing about the plant a galvanized iron collar 9 inches wide and of sufficient length to enclose an area from 12 to 18 inches larger than the prospective soil-ball. The collar is sunk into the ground to a depth of 3 inches and the soil banked up on the outside. The dilute carbon disulfide emulsion is then poured into the container thus formed and allowed to percolate through the soil about the roots of the plant. The soil is allowed to remain undisturbed for a period of 48 hours, at the end of which time the plant is dug and shipped. (See Fig. 7.)

This method of treatment has been in extensive use since 1924 and large numbers of ornamental trees and shrubs have been treated. In the spring of 1925, for instance, 30,000 conifer and broad-leafed evergreens were subjected to treatment.

Commercial carbon disulfide is a yellowish, heavy liquid with a disagreeable odor, which evaporates readily producing a very explosive vapor. **This material, or the emulsions of which it forms a part, must therefore be handled with utmost care as regards such hazards as fire and extreme heat. In fact the same precautions in handling this material should be exercised as in the handling of gasoline.**

Since carbon disulfide is practically insoluble in water, it is necessary for the purpose of soil treatments to render it miscible by emulsifying the compound with soap, preferably a resin soap. An emulsion of this kind is readily mixed in water in all proportions.

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[1] Contribution No. 30 Japanese Beetle Laboratory, Bureau of Entomology, United States Department of Agriculture, Riverton, N. J.

PREPARATION OF THE STOCK EMULSION

The stock emulsion of carbon disulfide is prepared as follows: to 135 cubic centimeters of 7 per cent sodium hydroxide solution add 50 grammes of powdered lump rosin. Then add 450 cubic centimeters of water and agitate thoroughly. Add 50 cubic centimeters of oleic acid and again agitate thoroughly. The best grades (C. P. or U. S. P.) of sodium hydroxide, rosin and oleic acid should be used. Thirty parts of the above soap mixture is added to 70 parts of carbon disulfide and the mixture agitated in a churn until emulsification occurs.[1]

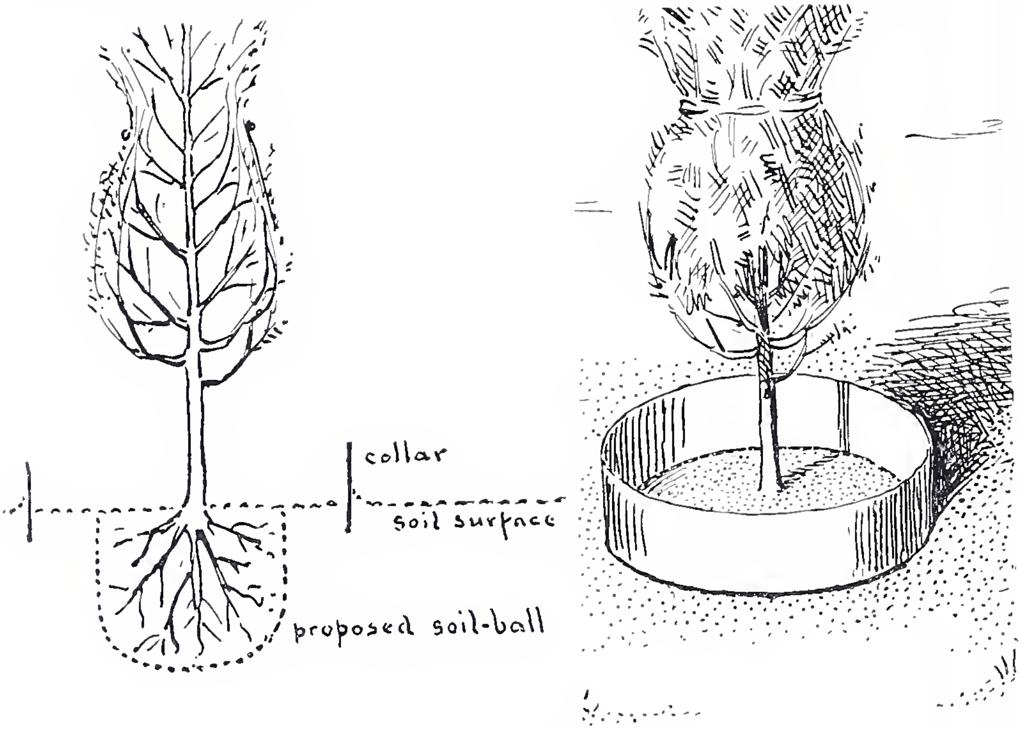

Fig. 7. Tree ready for treatment.

In view of the chemical composition of this emulsion, the formula is not one which can be readily put together by the layman. The emulsion, however, can now be purchased from certain manufacturers who prepare it according to the above formula.

THE TREATING SOLUTION

The concentration of carbon disulfide in the treating solution depends upon the temperature of the soil to be treated. The outline of this dosage range as affected by temperature is given in tables 1 and 2. It will be noted that the number of gallons of toxic liquid for each square foot of soil treated is constant and that the amount of carbon disulfide emulsion in each gallon increases gradually as the soil temperature decreases from 70° Fahr. to 40° Fahr. No treatments are made when the soil temperature is below 40° Fahr.

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[1] The formula of this emulsion is the work of Mr. J. W. Lipp.

This gradual increase in the concentration of the toxic solution is necessitated by the fact that the grub becomes more resistant to carbon disulfide solution as the temperature decreases. Fortunately, plants also increase in their resistance to the effects of carbon disulfide under the same conditions.

TREATMENT IN PRACTICE

Having obtained a quantity of the stock emulsion and galvanized iron strips or collars, the method of treating in general is as follows: Remove all trash, weeds, etc., from the soil area about the base of the plant to be treated. If there are any low hanging branches present tie them up. Level the soil to be treated, disturbing it as little as possible. Having in mind the size of the soil-ball which is to be removed in subsequently digging the tree, figure the diameter of the area to be treated as one foot greater than the diameter of the proposed soil-ball. Take one of the galvanized iron strips, bend it into a circle with the ends overlapping and place it around the base of the plant, drawing in the ends until the required diameter is obtained. If the soil is light in texture, the strip can be pounded into the soil for a depth of three inches with the back of a spade. If the soil is heavy in texture, on the other hand, it may be necessary to make a channel 2 or 3 inches deep with the tip of the spade so that the galvanized iron strip can be fitted down into it. Having placed the strip in position, firm the soil adjoining the metal on both sides with the foot and **level the soil inside the basin thus formed.** As an added precaution soil may be banked up against the outside of the galvanized iron to a height of 3 or 4 inches. The basin is now ready to receive the dilute carbon disulfide emulsion.

Where the area to be treated about a plant is more than 4 feet in diameter or when plants are growing closely together in beds it is advisable to use square collars. These vary in size from 1 to 4 feet square. They are placed one against the other, thereby reducing to a minimum the danger of uneven distribution of the liquid, since it has been found in practice that leveling on soil more than 4 feet wide is difficult.

DETERMINATION OF DOSAGE NECESSARY

The concentration of carbon disulfide to be employed depends upon the soil temperature. The temperature is determined by taking the soil temperature at 7 or 8 A. M. at a depth of 3 and of 9 inches and averaging the result. The schedules given are based on the lowest soil temperature encountered in a given period of treatment.

PREPARING THE TOXIC LIQUID

Let us suppose that the soil temperature taken as above on a given day, determined as above, is 52° Fahr. Schedule No. 3, Tables 1 or 2 should be employed. Give the container of the stock emulsion a mild

Table 1. Treating Solution for Circular Collars

Important: **Pour on equal volume of water into an equal volume of stock emulsion before using this table.**

Diameter of the Collar (inches)	Gallons of Water	Cubic Centimeters of Diluted Stock Emulsion					
		(1) 40°–45°	(2) 45°–50°	(3) 50°–55°	(4) 55°–60°	(5) 60°–65°	(6) 65°–70°
12	1.5	13.25	12.25	11.25	10.50	9.50	7.50
14	2.0	17.50	16.25	15.00	14.00	12.50	10.00
16	3.0	26.25	24.50	22.50	21.00	19.00	15.00
18, 19, 20	4.0	35.00	32.50	30.00	27.50	25.00	20.00
21, 22	5.0	44.00	40.75	37.50	34.00	31.50	25.00
23, 24	6.0	53.00	49.00	45.00	41.00	37.50	30.00
25, 26	7.0	61.00	57.00	52.50	48.00	44.00	35.00
27, 28	8.0	70.00	65.00	60.00	55.00	50.00	40.00
29, 30	9.0	79.00	73.00	67.50	62.00	56.00	45.00
31, 32	10.0	88.00	81.00	75.00	69.00	62.00	50.00
33	11.0	96.00	89.00	82.50	76.00	69.00	55.00
34, 35	12.0	105.00	98.00	90.00	83.00	75.00	60.00
36	13.0	114.00	106.00	97.50	90.00	81.00	65.00
39	15.0	131.00	122.00	113.00	103.00	94.00	75.00
42	18.0	158.00	146.00	135.00	124.00	113.00	90.00
45	20.0	175.00	163.00	150.00	138.00	125.00	100.00
48	23.0	201.00	187.00	173.00	158.00	144.00	115.00

Table 2. Treating Solution for Square Collars

Important: Pour an equal volume of water into an equal volume of stock emulsion before using this table.

Size Collar (inches)	Gallons of Water	Cubic Centimeters of Diluted Stock Emulsion					
		(1) 40°–45°	(2) 45°–50°	(3) 50°–55°	(4) 55°–60°	(5) 60°–65°	(6) 65°–70°
12 x 12	1.8	15.75	14.75	13.50	12.50	11.25	9.00
14 x 14	2.5	22.00	20.50	18.75	17.00	15.50	12.50
16 x 16	3.0	26.25	24.50	22.50	21.00	19.00	15.00
18 x 18	4.0	35.00	32.50	30.00	27.50	25.00	20.00
20 x 20	5.0	44.00	41.00	37.50	34.50	31.00	25.00
24 x 24	7.0	61.00	57.00	53.00	48.00	44.00	35.00
36 x 36	16.0	140.00	130.00	120.00	110.00	100.00	80.00
48 x 48	29.0	254.00	236.00	218.00	200.00	181.00	145.00

shaking and draw off a pint or a quart of the emulsion, depending upon the number of trees to be treated. Add to this an equal volume of water and shake. This mixture should be shaken before measuring out each dosage, as there is a tendency for it to stratify.

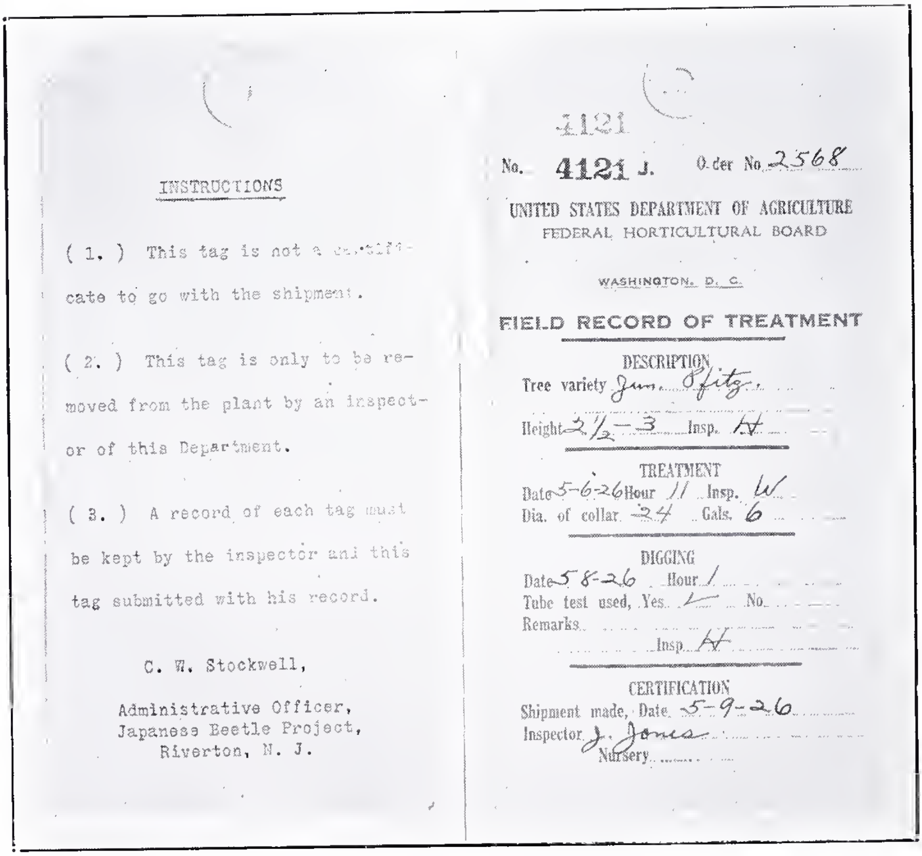
Let us suppose the diameter of the collar placed as above is 24 inches. This calls for 6 gallons of liquid and 45 cubic centimeters of the diluted stock emulsion. Place, therefore, 6 gallons of water in a galvanized iron ash can, or similar receptacle, measure the 45 cubic centimeters of the emulsion with a graduate, pour it into the water and stir with a paddle. Pour the resulting liquid into the basin about the tree so as to avoid splashing and undue soil disturbance. The liquid will gradually penetrate into the soil, the length of time required depending upon the nature of the soil and the moisture content of the soil. The collar and the soil therein must not be disturbed for a period of 48 hours, at the end of which period the tree may be dug, wrapped in burlap and shipped.

Every step in the above treatment is carried out under the direct supervision of an official inspector, and the nurseryman, or those doing the work, are subject at all times to his orders. As an added check on the efficiency of the individual treatments a certain proportion of the plants to be treated are artificially infested by the inspector with grubs of the Japanese beetle, contained in small wire cages which are afterwards removed for observation. Whether a given plant may be shipped even after treatment rests entirely with the inspector in charge of the treatment.

CONDITIONS INHIBITING TREATMENT

There are certain conditions encountered in treatments in practice which experience has shown to be not conducive to securing the desired results. Where such conditions are not readily modified by slight adjustments in treating methods, it has been the policy to refuse treatment. When the following conditions are encountered, treatment is almost invariably refused:

1—High water table and inadequate drainage.
2—Hillsides where a level basin cannot be obtained.
3—Fabricated soils in which peat content is high.



INSTRUCTIONS

(1.) This tag is not a certificate to go with the shipment.

(2.) This tag is only to be removed from the plant by an inspector of this Department.

(3.) A record of each tag must be kept by the inspector and this tag submitted with his record.

C. W. Stockwell,

Administrative Officer,
Japanese Beetle Project,
Riverton, N. J.

4121

No. 4121 J. Order No. 2568

UNITED STATES DEPARTMENT OF AGRICULTURE
FEDERAL HORTICULTURAL BOARD

WASHINGTON, D. C.

FIELD RECORD OF TREATMENT

DESCRIPTION
Tree variety Jun. Pfitz.
Height 2½-3 Insp. H

TREATMENT
Date 5-6-26 Hour 11 Insp. W
Dia. of collar 24 Gals. 6

DIGGING
Date 5 8-26 Hour 1
Tube test used, Yes ✓ No
Remarks
Insp. H

CERTIFICATION
Shipment made, Date 5-9-26
Inspector J. Jones
Nursery

Fig. 8. The inspection tag.

4—Ground which has been tunnelled and undermined by moles and rodents.
5—Plants which have been recently transplanted.

EFFECT OF TREATMENT UPON PLANTS

Plants which have been root-pruned so that they possess a deep mass of fibrous roots at the time of treatment are rarely injured by the treatment. Plants which have not been root-pruned may be seriously injured by the treatment. Such stock lacking in fibrous roots is transplanted with difficulty under any condition. Late spring treatments, when growth is progressing rapidly, has not been entirely satisfactory.

QUARANTINE SYSTEM OF RECORDS IN THE FIELD

The system of keeping records of individual tree treatments by means of a tag placed on each plant treated is shown in Fig. 8. Number 4121 refers to the government record, while order number 2568 refers to the nurseryman's record. The tree variety, with height, has in this instance been determined by inspector "H" at the time when the tag was fastened on the tree. The date and hour of treatment, diameter of collar and number of gallons of solution used has been determined and supervised by inspector "W." Two days later the tree was dug under supervision of inspector "H." As it happens, in this particular instance, the tree was artificially infested with grubs in wire tubes, as shown by the record. It will be seen that the record of each and every step of the treatment of individual trees is supervised and recorded by an official inspector.